

a second electrode formed on an upper surface of each of the piezoelectric members;

and

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Conc*

a second flexible printed wiring board having a plurality of pattern wires each having a width smaller than a width of each of the piezoelectric members in an array direction, leading an electric wire from each of the second electrodes, and connecting the electric wire to ground.

REMARKS

Favorable reconsideration of this application as presently amended and in light of the following discussion is respectfully request.

Claims 1-11 are presently active in this case. Claims 8-10 have been amended and claim 11 has been added by way of the present amendment.

In the outstanding office action, the drawings were objected to for failing to comply with 37 CFR 1.84(p)(5); the disclosure was objected to for including an informality; claim 9 was objected to for including an in informality; claim 10 was rejected under 35 USC 112, second paragraph, for being indefinite; claims 8 and 10 were rejected under 35 USC 102(e) as being anticipated by Gilmore; claims 1 and 2 were rejected under 35 USC 103(a) as being unpatentable over Saitoh et al. in view of Lewandowski et al.; claims 4, 5, and 7 were rejected under 35 USC 103(a) as being unpatentable over Greenstein in view of Gilmore; and claim 6 was rejected under 35 USC 103(a) as being unpatentable over Greenstein in view of Gilmore and Brisken et al. Claims 3 and 9 were indicated as being allowable. Applicants acknowledge with appreciation the indication of allowable subjects matter.

In response to the object to the drawings, reference No. 444 in the specification has been changed to 440 throughout. Regarding reference No. 440a, Applicants point out that reference No. 440a is recited on page 31 at lines 22, 23, and 26 of the specification. Regarding reference No. 445, Applicants respectfully point out that reference No. 445 is

recited on page 31 at line 9 of the specification. Consequently, no more objections to the drawings are believed to be outstanding.

In response to the objection to the disclosure, the disclosure has been rewritten as suggested in the office action. No further objection on this basis is therefore anticipated.

In response to the objection to claim 9, claim 9 has been amended as suggested in the office action. No further objection on this basis is therefore anticipated.

In response to the objection to claim 10 under 35 USC 112, second paragraph, claim 10 has been rewritten to clarify that the piezoelectric vibration element array has a width smaller than a width of each of the conductive layers. Consequently, no further rejection on this basis is anticipated.

Claims 8 and 10 stand rejected under 35 U.S.C. 102(e) as being anticipated by Gilmore. However, Applicants submit that these claims are novel and non-obvious. That is, the probe and probe manufacturing method of claims 8 and 10 are patentably distinguishable from those of Gilmore in light of the structure of the pattern wires of the flexible printed wiring boards.

According to claims 8 and 10, each of the pattern wires of a first flexible printed wiring board has a width smaller than the width of each piezoelectric member in an array direction and extends in the longitudinal direction of each piezoelectric member. In contrast thereto, the probe shown in Gilmore does not have a pattern wire extending in the longitudinal direction of a piezoelectric member. Because of this structural difference, the probe of claims 8 and 10 is advantageous not only in that the generation of chipping or the like is prevented in the manufacturing process, but also in that a reliable connection to the piezoelectric members is attained. Neither the identified structural difference or the attendant advantage thereof is disclosed or suggested by Gilmore.

Furthermore, Gilmore does not disclose anything as to what structure is needed or desired for pattern wires extending in the longitudinal direction of the piezoelectric member. Moreover, Gilmore does not provide any motivation to modify the structure of Gilmore in such a manner.

Claims 1 and 2 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Saitoh et al. in view of Lewandowski et al. Applicants respectfully traverse that rejection. Applicants submit that the ultrasonic probe of claims 1 and 2 is not rendered obvious by the asserted combination of references.

The technical concept underlying claims 1 and 2 lies in the formation of at least one of the upper resin layer and the under resin layer. These layers serve to protect piezoelectric members in the cutting step. In addition, since the resin layers are conductive, they function as electrodes as well. As recited in the claims, the resin layers must have an acoustic impedance smaller than that of the piezoelectric members. Therefore, the resin layers having these characteristics also function as matching layer (see page 20, lines 7-14 of the specification for example).

The office action asserts that the present invention is obvious while paying attention only to the material of the electrode of the present invention. The office action states that it would have been obvious to replace the metallic electrode described in Saitoh et al. with a conductive resin electrode on the basis of the disclosure in Lewandowski et al. Even if the material of Saitoh et al. could have been changed to another kind of material, that change would not have motivated one with ordinary skill in the art to use a resin electrode, let alone provided a resin electrode with the impedance and cutting characteristics provided for by the claims.

Lewandowski et al. merely disclose an example of an electrode formed of conductive resin. The Lewandowski et al. reference is non-analogous to the technology regarding

ultrasonic probes and does not disclose anything suggestive of the technical concept of the present invention. Hence, Applicants submit that the combination of Saitoh et al. and Lewandowski et al. does not render obvious the subject matter of claims 1 and 2.

Claims 4, 5, and 7 stand rejected under 35 USC 103(a) as being unpatentable over Greenstein in view of Gilmore. Furthermore, claim 6 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Greenstein in view of Gilmore and further in view of Brisken et al. Applicants respectfully traverse those rejections. Applicants submit that the ultrasonic probe manufacturing method recited in claims 4, 5, and 7 would not have been obvious over the asserted combination of references. The technical concept underlying claims 4, 5, 6 and 7 is that at least one of an upper resin layer and an under resin layer is provided to protect the piezoelectric members in the cutting step. The resin layers are conductive, hence they function as electrodes as well. As recited in the claims, the resin layers must have an impedance smaller than that of the piezoelectric members.

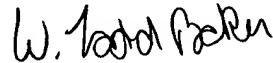
The office action asserts that the invention defined by each claim is obvious while paying attention only to the piezoelectric member having a resin layer formed thereon. The office action states that the step of manufacturing a piezoelectric member having a resin layer is disclosed in Greenstein and that the other steps of the present invention are suggested in Gilmore or Brisken et al. However, the resin layer 16 disclosed in Greenstein functions as a backing member (see column 4, lines 32-42 of Greenstein). As long as the resin layer is used as such, it is unrelated to the technical concept of the present invention, wherein at least one of an upper resin layer and an under resin layer is intentionally provided for a piezoelectric member, and the impedance of the resin layer is smaller than that of the piezoelectric member. Used as a backing member, the resin layer 16 of Greenstein must be provided at a position behind the piezoelectric member, not at the other positions. Therefore, Greenstein is unrelated to the technical concept of the present invention, wherein a resin layer is formed on

at least one of the upper and lower surfaces of a piezoelectric member so as to protect that piezoelectric member in the cutting step. Consequently, Greenstein is not believed to anticipate or render obvious the subject matter defined by claims 4-7 when considered alone or in combination with Gilmore and Brisken et al.

Consequently, in view of the present amendment, no further issues are believed to be outstanding in the present application, and the present application is believed to be in condition for formal allowance. An early and favorable action is therefore respectfully requested.

Respectfully submitted,

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IN THE SPECIFICATION

Page 4, please amend paragraph at lines 13 to page 6, line 1 as follows:

Hence, we have proposed a structure as shown in FIG. 1D (Japanese Patent Application KOKAI Publication No. 2000-14672) as an ultrasonic probe using single crystal of this kind, and have tried to improve the probe manufacture yield. FIG. 1D shows a cross-sectional view structure of an array probe using a single-crystal vibration element. Electrodes 4 and 5 are formed on both sides of the single-crystal vibration element 1, and a backing material 2 is provided on the lower surface of the vibration element 1. In addition, acoustic matching layers 3a and 3b are formed on the single-crystal vibration element, so that the single-crystal vibration element 1 and the matching layers 3a and 3b are subjected to array processing. The array pitch of the array probe is about 0.1 mm in case where the pitch is small. Further, transmission/ reception of an [ultraviolet] ultrasonic wave is carried out through an acoustic lens 8 provided on the acoustic matching layer 3b. The electrodes 4 and 5 formed on the both surfaces of the single-crystal vibration element 1 are connected to a cable through FPCs 6 and 7 and thus connected to a diagnosis apparatus (omitted from figures). In the structure shown in FIG. 1D, the FPC 6 is joined to the vibration element by an epoxy-based adhesion throughout the all surface of the vibration element, by extending the conductive layer of the FPC so as to correspond to the area of the vibration element. Metal Cu is generally used as the conductive layer. FIG. 1E shows a conductive layer at a lower portion of the signal FPC shown in FIG. 1D, viewed from the single-crystal vibration element

1. The conductive layer 6a' of the signal FPC shown in FIG. 1D is led like a hound's tooth check as shown in FIG. 1E. This array structure is prepared in the manner explained below. Electrodes 4 and 5 are formed on the single-crystal vibration element 1 having an integral shape. A vibration element to which a FPC is adhered is adhered to the backing member 2. Acoustic matching layers 3a and 3b are formed, and thereafter, a dicing saw is used to cut them from the side of the matching layer. Thereafter, the acoustic lens 8 is formed on the acoustic matching layer 3, and preparation is thus completed.

Page 10, please amend the paragraph at lines 9 to 16 as follows:

The probe according to the fifth aspect further comprises: a second electrode formed on an upper surface of each of the piezoelectric members; and a second flexible printed wiring board having a plurality of pattern wires each having a width smaller than a width of each of the piezoelectric member in an array direction, for leading and connecting an electric wire from each of the second electrode to [GND] grand.

Page 15, please amend the paragraph at lines 14 to 23 as follows:

The backing member 25 is provided on the back surface of the flexible wiring board 23 and mechanically supports the composite piezoelectric member 11. Also, the backing member [20] 25 breaks the composite piezoelectric member 11 to shorten ultrasonic pulses. The thickness of this backing member [20] 2 is maintained at a sufficient thickness (enough to damp) relative to the wavelength of the ultrasonic frequency to be used, in order to maintain excellent acoustic characteristics of the transducer.

Page 25, please amend the paragraph at lines 10 to 19 as follows:

Kerfs having a depth of [700] 800 μm (100 μm uncut) are cut like an array at a pitch of 200 μm , by a dicing saw with a blade having a thickness of 50 μm , in a piezoelectric member 11 sandwiched between PVC resin layers 3 and 4 containing silver, which are formed in the second step. Epoxy resins 12 are filled and hardened in the cut kerfs. Likewise,

similar cut kerfs are formed vertically to the cut kerfs described above, and epoxy resins 12 are also filled and hardened therein.

Page 25, please amend the paragraph at lines 20 to 26 as follows:

Thereafter, the member is temporarily fixed to a glass plate with the uncut side set as a lower surface, and the layer in the opposite side is polished to 150 µm by a plane polisher. Further, the uncut side set as an upper side is also polished to 150 µm. That is, the lower PVC resin layer 113 in the uncut side is [kept uncut] divided even after this polishing.

Page 26, please amend the paragraph at lines 10 to 21 as follows:

At first, a common electrode plate 21 is connected to the upper PVC resin layer 113 in the uncut side, and a flexible wiring board 8 provided with a two dimensional signal wiring is connected to the opposite surface throughout the overall surface. A second acoustic matching layer 19 is formed in the side of the ultrasonic wave radiation surface and is thereafter adhered to a backing member 25 by epoxy resins. A silicon-based acoustic lens 19 is adhered thereto. Uniformly in the signal side of the FPC, a voltage of 1 KV/mm is applied between the signal side and the [GND] grand side.

Page 30, please amend the paragraph at lines 26 to page 31, line 13 as follows:

A predetermined electric power is applied to or detected from the electrodes 40 and 50 through the flexible wiring boards 42 and 44, respectively. The first flexible wiring board 42 is a multi-layer board comprised of a conductive layer 420 made of copper or the like and an insulating layer 421 made of a polyimide film or the like, and serves to make [GND] grand connection. Also, the second flexible wiring board 44 is a multi-layer board comprised of conductive layers 440 and 442 made of copper or the like, and insulating layers 441, 443, and 445 made of polyimide films or the like, and electrically connects the probe 35 with the body of an ultrasonic diagnosis apparatus. Note that the conductive layer [444] 440 has a predetermined wiring pattern described later (see FIG. 7).

Page 32, please amend the paragraph at lines 10 to 26 as follows:

According to this kind of probe 35, the first and second flexible wiring boards 42 and 44 are set at a pitch width equal to or smaller than that of the array arrangement of the single-crystal piezoelectric members 111. Therefore, in cutting for forming an array arrangement, the conductive layer [444] 440 and the single-crystal piezoelectric member 111 need not be cut simultaneously. That is, since the conductive layer [444] 440 and the single-crystal piezoelectric member 111 which have cutting characteristics different from each other are not cut simultaneously, it is possible to restrict occurrence of cracking and chipping in manufacture of arrays. Also, occurrence of cracking and chipping can be restricted by cutting the single-crystal piezoelectric member 111 with the first flexible wiring boards 42 and the second flexible wiring boards 44 connected.

Page 35, please amend the paragraph at lines 15 to page 36, line 4 as follows:

FIG. 10 is an explanatory view for the schematic structure of an ultrasonic probe 50 according to the seventh embodiment. Note that this figure shows a condition before the first electrode 40 and the second electrode 50 are adhered to the second flexible wiring board 44. In FIG. 10, the first electrode 40 for [GND] grand is a detour electrode which continues from the upper surface of the single-crystal piezoelectric member 111 through a side surface thereof to the lower surface thereof. The first electrode 40 is connected to a conductive layer 442 of the second flexible wiring board 44, and the second electrode 50 is connected to a conductive layer 440 of the second flexible wiring board 44. Note that an exposed part is provided for each of the conductive layers 442 and 440, in consistence with each of the electrodes 40 and 50 of the single-crystal piezoelectric member 111.

Page 36, please amend the paragraph at lines 17 to 23 as follows:

Compared with the ultrasonic probe 50 shown in FIG. 10, a gap is eliminated between the conductive layer 442 and the conductive layer [444] 440 of the probe 51 shown in FIG.

11. Therefore, with this structure, it is possible to prevent breakdown of the single-crystal piezoelectric member 111 which can be caused by pressed adhesion.

IN THE CLAIMS

Please amend Claims 8-10 as shown in the attached marked-up claims to read as follows:

8. (Amended) An ultrasonic probe comprising:

a plurality of piezoelectric members formed of solution-based single-crystal containing at least plumbum titanate, and arranged like an array;
a first electrode formed on a lower surface of each of the piezoelectric members; and

a first flexible printed wiring board having a plurality of pattern wires each having a width smaller than a width of each of the piezoelectric members in an array direction, extending in a longitudinal direction of each of the piezoelectric members, [for leading and connecting] and configured to lead and connect an electric wire from each of the first electrode to an ultrasonic diagnosis apparatus body.

9. (Amended) The ultrasonic probe according to claim 8, further comprising:

a second electrode formed on an upper surface of each of the piezoelectric members; and
a second flexible printed wiring board having a plurality of pattern wires each having a width smaller than a width of each of the piezoelectric members in an array direction, [for leading and connecting] and configured to lead and connect an electric wire from each of the second electrode to ground [GND].

10. (Amended) A method of manufacturing an ultrasonic probe, comprising:

a first step of adhering a flexible printed wiring board and a single-crystal piezoelectric member to each other, the flexible printed wiring board having conductive layers each having a predetermined width, which are patterned in parallel on a resin member; and

a second step of cutting the flexible panted wring board and the single-crystal piezoelectric member together, along and between the conductive layers, thereby to form a piezoelectric vibration element array having a [pitch] width smaller than a [the] width of each of the conductive layers.